

Biological Research and Monitoring Subactivity

Subactivity	1999 Estimate	Uncontrol. & Related Chgs.	Program Redirect	Program Changes	FY 2000 Budget Request	Change from 1999
Biological Research and Monitoring	138,521	1,892	-35,669	-7,010	97,734	-40,787
Total Requirements \$000	138,521	1,892	-35,669	-7,010	97,734	-40,787

Note: The Program Redirect column reflects the redirection of funds to the Integrated Science, Science Support, and Facilities activities. The Uncontrollables & Related Changes column includes a decrease of \$1.3 million for the transfer to FWS for the San Marcos Field Station (\$300) and a one-time add in FY 1999 for the incinerator replacement in Madison, Wisconsin (\$1.0 million).

Current Program Highlights

The Biological Research and Monitoring subactivity generates specialized biological research and monitoring information needed to effectively manage and conserve biological resources. Our Nation's biological resources are an increasingly valuable and vulnerable part of our country's heritage and economy. These varied, widely distributed, and complex resources extend from the polar bear habitats of the Arctic to the seagrass beds of the Florida coast. They encompass the aquatic treasures of the Great Lakes as well as the beauty and extreme conditions of the southwest deserts. They are isolated islands of incredible diversity such as Hawaii, and they are large interconnected waters like the Mississippi River. The types of habitats that we live alongside include mountains, forests, rangelands, wetlands, coasts, and open waters. The products of these habitats provide us with food, energy, medicine, transportation, and enjoyment.

Research is needed to reduce and avoid the costs of controlling and eradicating invasive species, these costs may reach \$100 billion over the next 50 years. Investigations to evaluate the threats posed by toxic substances can aid in determining the most effective regulations. Studies are required to help contain and eradicate diseases which can devastate regional populations; single disease outbreaks have killed 300,000 or more waterfowl and outbreaks resulting in 10,000 or more deaths occur almost every year. Monitoring of environmental conditions and populations is critical to providing the yardstick by which the success of management strategies and resource policies is measured.

Management responsibility for biological resources falls on a number of State and Federal Government agencies. Federal lands and biological resources are primarily managed by the Department of the Interior (DOI). DOI land and resource management bureaus need the scientific understanding and the technical tools to be able to wisely manage lands and resources on a sustainable basis.

To develop the biologic information needed by land and resource managers, the USGS Biological Research and Monitoring Subactivity, has organized its research and monitoring activities around eight program areas: fisheries and aquatic resources, wildlife, status and trends, endangered and at risk species, ecosystems, contaminants, exotic species, and applications of science information to management. Grouping science within program areas provides an opportunity to plan and promote integration and cohesion among individual science projects and allows for periodic evaluations of accomplishments.

Table 1 displays the Biological Research and Monitoring subactivity funding as shown in previous budget narratives. Table 2 displays the Biological Research and Monitoring subactivity in the context of the new program areas. Fiscal year 1999 is shown in both tables to show the transition in how the research and monitoring science activities are depicted. It should be noted that the subactivity funding level is the same in either mode of presentation.

Biological Research and Monitoring Program Areas (\$000)

Program Areas	FY1998 Actual	FY1999 Enacted
Status & Trends of Biological Resources		
Populations and Communities	11,967	12,288
Habitats, Ecosystems, and Landscapes	7,402	7,537
Subtotal	19,369	19,825
Investigations of Biological Resources		
Biology of Critical Species	27,811	31,019
Ecology of Habitats, Ecosystems, and Landscapes	14,463	21,928
Subtotal	42,274	52,947
Threats to Biological Resources		
Environmental Change	19,009	20,630
Invasive Species	4,939	5,029
Subtotal	23,948	25,659
Tools for Natural Resource Managers		
Science in Support of Management Alternatives	11,691	12,210
Technology & Methods	2,177	2,777
Subtotal	13,868	14,987
Science & Research Center Support	23,356	25,103
Total Biological Research & Monitoring	122,815	138,521

Table 1

Biological Research and Monitoring Subactivity

Revised Program Areas	FY 1999 Enacted	FY 2000 Request
Status & Trends Consists of parts of: Status & Trends; Tools for Natural Resources Managers-Technology & Methods	21,009	17,803
Contaminants Consists of parts of: Threats to Biological Resources-Environmental Change	10,598	9,667
Fisheries & Aquatic Resources Consists of parts of: Investigations of Biological Resources-Biology of Critical Species; Tools for Natural Resource Managers-Technology & Methods	13,384	11,771
Wildlife Consists of parts of: Investigations of Biological Resources-Biology of Critical Species	15,041	16,369
Ecosystems Consists of parts of: Investigations of Biological Resources-Ecology of Habitats, Ecosystems, and Landscapes	32,004	22,523
Application of Science Information to Management Consists of parts of: Tools for Natural Resource Managers-Science in Support of Management Alternatives, Technology & Methods	3,008	2,052
Endangered & At-Risk Species Consists of parts of: Investigations of Biological Resources-Biology of Critical Species; Tools for Natural Resource Managers-Science in Support of Management Alternatives	13,367	12,382
Exotic (Non-Indigenous) Species Consists of all of: Threats to Biological Resources-Invasive Species	5,007	5,167
Science & Research Center Support	25,103	0
Total Biological Research & Monitoring	138,521	97,734

Table 2

Note: In FY 2000 the Science & Research Center Support funding is included in the Science Support and Facilities activities.

To make biological science activities readily available to all interested parties, the Science Information System (SIS), an automated query system has been developed. The SIS is designed to meet the information needs of scientists and resource managers; both within the USGS and Department of the Interior and in partner organizations, client agencies, and special interest groups. Its purpose is to provide a comprehensive scientific information database containing summary descriptions of the objectives, location, funding sources, general approach, and anticipated applications of results of USGS scientific efforts. Metadata on projects that contribute to Biological Research and Monitoring program areas are included in the SIS database. The SIS may be accessed and queried on the world wide web at <http://cristel.nal.usda.gov:8080/star/brd.html>.

The following describes the Biological Research and Monitoring subactivity under the new, FY 2000 program areas.

Status and Trends

Biological status and trends science integrates inventory and monitoring efforts and current historical data sets with a focus on DOI trust resources and lands. This program area seeks to provide an integrated monitoring approach that describes and tracks the abundance, distribution, productivity, and health of the Nation's plants, animals, and ecosystems. It encompasses activities at the landscape, community, population, and genetic levels and develops inventory and monitoring techniques and statistical methods specifically applicable to DOI land and resource management needs. While focused on Department lands, information is also useful to other public and private organizations. Regular assessments and analyses of biological resources help policymakers and the public make informed decisions about their management, while maintaining the health, diversity, and ecological balance of biological resources. The work involves extensive cooperation with Federal, State, and private agencies and organizations.

Science Support for Management of Department of the Interior Lands Integrated Natural Resource Inventory and Monitoring

As land management agencies find themselves with enhanced mission commitments and new legal mandates to assure the sustainability of park ecosystems, the need for integrated inventory and monitoring guidelines and criteria that can be extrapolated across broad landscapes and include multiple spatial and temporal scales is urgent. Based on consensus by DOI Science Board, the USGS Status and Trends program convened a multi-bureau task group to develop a framework for integrated inventory and monitoring for: riparian areas, aquatic and terrestrial Invasive species; threatened and endangered species; amphibians; and landscape-level ecosystems and biological communities. Standardized protocols and technology, as determined by an in-depth assessment of documented inventory and monitoring programs and methodologies--or newly designed if required, will provide the basic inventory and monitoring framework.

Initially, a cooperative DOI effort established in a biogeographical region of ecological interest to DOI agencies has been developed as a short-term pilot. The results will provide the information needed to better structure a credible long-term inventory and monitoring program across a broad landscape, define an effective and efficient process for inventory and monitoring and doing business across multiple DOI agencies and begin institutionalizing long-term inventory and monitoring to assess the Status and Trends of the Nation's natural resources by the USGS.

National Park Monitoring – The NPS is the steward of significant natural resources that occur in more than 265 units of the National Park System. Legal mandates require the establishment of scientifically-based programs to ensure the protection and preservation of these natural resources as a key element of their park management. To deal with natural resource management concerns, a long-term prototype monitoring program that evaluates the status and trends of selected ecological communities has been developed by the NPS. To meet the needs of individual park programs, in 7 biogeographical regions, USGS scientists assist in the development and/or evaluation of the prototype monitoring framework, statistical design and methodology. A goal of the prototype program is to provide high quality credible methods and tools that are adaptable for use in other parks, refuges, or on DOI lands within similar ecological areas.

National Park Monitoring

The prototype monitoring program at Cape Cod National Seashore has hosted a long-term coastal ecosystem monitoring conference to initiate the transfer of monitoring methods to other coastal parks. Ten coastal parks participated in the conference discussion. The talks focused on how to integrate a prototype program throughout the Seashore biogeographical region.

Bird Monitoring — Patuxent Wildlife Research Center is developing an electronic data center that will permit ready access to the most important bird population monitoring databases in North America. At the core of this center is the Breeding Bird Survey (BBS) database, which can provide long-term information on population changes in nearly 500 bird species. The BBS, originally a Fish and Wildlife Service program and now managed by USGS, has been the single most important source of guidance for migratory nongame bird conservation programs in the United States over the past two decades. The data center also provides access to the National Audubon Society's Christmas Bird Count database, the most comprehensive database on North American birds during the winter season. A database on colonial waterbirds (herons, terns, etc.) is presently being developed, and a prototype system for the extensive Partners-in-Flight "point count" database will be tested soon. In the future, population information on other bird groups, such as shorebirds, will be targeted for inclusion. The data center is evolving as a series of data-sharing partnerships between USGS and other agencies and organizations and will feature the option of data access through the Internet. For data that are the property of other organizations, the nature of the partnerships will vary from actual co-management of data to simple computer linkages between USGS and the organization. As a "one-stop-shopping" site for bird population information, the national bird population data center will become an indispensable resource for wildlife managers at the Federal, State, and local levels.

Mammal Monitoring — USGS scientists have partnership efforts to monitor the status and trends of wildlife populations that extend from the Arctic to Yellowstone to the Everglades of Florida. Reports by USGS scientists to commissions charged with oversight for these wildlife populations, such as the Arctic Research Commission and the Marine Mammal Commission, include population studies of polar bears in the Beaufort Sea and the status and trends of polar bears in the state of Alaska. Methods for measuring population changes of moose have been reported and are key to Yellowstone National Park resource management. Improved methods for determining the distribution of swift foxes in Kansas, and the continued enhancement and input of science information for the Manatee Photo Identification System,

which provides the ability to determine survival rates of the manatee, are each important to the DOI agencies responsible for their stewardship.

Amphibian Monitoring – In the face of growing recognition that many species of frogs, toads, and salamanders are experiencing alarming population declines, USGS has been stepping up its amphibian monitoring efforts. The North American Amphibian Monitoring Program, coordinated by USGS and implemented largely by State natural resource agencies, has expanded to include 28 States and 6 Canadian provinces. The standardized methodology used enables all data collected to be consolidated and analyzed at the Patuxent Wildlife Research Center. Methods for surveying and monitoring salamander populations are also being developed to provide States with tools for tracking populations of their vulnerable salamander species. Surveys and related methods are being tested in Shenandoah National Park, Virginia; Big Bend National Park, Texas; and Point Reyes National Seashore, California. Even in these pristine areas amphibians have been shown to be vulnerable to environmental stresses.

Fish Monitoring — In cooperation with States, tribes and other Federal agencies, the USGS collects, analyzes and interprets data on Great Lakes fishery resources and on anadromous and interjurisdictional species on the Atlantic, Pacific and Gulf Coasts. The development of accurate census techniques, improved population dynamics models, and statistically valid methods for quantifying environmental and harvest effects are critical parts of this research. Information gathered and disseminated allows resource managers to effectively regulate the harvest, identify populations that may become threatened and reduce mortality levels.

Improved Sampling Techniques for Great Lakes Fishes

USGS scientists completed a five-year study to adapt and refine the use of acoustic technology to enhance the assessment and study of Great Lakes fishes. Use of acoustic sampling techniques, when fully integrated with existing surveys, will greatly enhance sampling and study of Great Lakes fish communities by the USGS and our Federal, state, and tribal partners.

Offshore Environmental Studies (Monitoring) — Offshore environmental studies conducted by the USGS provide environmental monitoring information to the Department's Minerals Management Service (MMS) for use in offshore oil and gas exploration development and production decision making. Scientists are studying factors responsible for apparent large-scale declines in populations of amphibians, the introduction of predatory fish, and epidemic disease are all possible causes of declines. Monitoring efforts in the Gulf of Mexico have generated monitoring information which help to explain the effects of offshore oil and gas activities on marine biota. In some cases these data can be used to develop mitigating measures and stipulations for offshore oil and gas operations. In Alaska, USGS scientists provide seabird/forage fish and shorebird monitoring data to the MMS.

Standards and Protocols — USGS scientists are continuing to develop standards and protocols for the implementation of many different inventory and monitoring projects. Monitoring protocols and methods include statistical sampling designs and adhere to the standards of the National Spatial Data Infrastructure. Examples include: protocols for all taxa biodiversity inventory in the Great Smoky Mountains National Park, mist-net inventory and monitoring of bats in Pacific Northwest forests, citizen monitoring of benthic communities in

relation to land management changes, using DNA to monitor grizzly and black bear populations, assessing reconstructed depressional wetlands in the Mid-Atlantic states assessing relative habitat value of the restored versus natural coastal marshes to migratory birds in Chesapeake Bay, and for behavioral indices of contaminant stress in aquatic organisms.

Taxonomy, Systematics, and Museum Studies — USGS scientists located at the National Museum of Natural History, a major repository of information important in the conservation of species, evaluate the current systematic status of species, study variation in natural communities of animals, and serve as a clearinghouse for accurate information of wildlife species. Curation of the North American vertebrate collections at the Smithsonian Institute involve long-term collection of both the specimens and the data on the specimens as well as management of a long-term data base.

Recent Accomplishments

World's Largest Seagrass Inventory Completed — The USGS National Wetlands Research Center mapped the distribution of seagrass habitat in the northeastern Gulf of Mexico. This project covered over 2000 miles of shoreline from the Chandeleur Islands of Louisiana to Anclote Key, Florida. The mapping was based on 1992 natural color 1:24,000 scale aerial photography and followed a standardized mapping protocol and classification system. This is the largest seagrass mapping project to date in the world (950,000 acres of seagrass). Funding and staff partners for ground truthing and peer review include the EPA's Environmental Management Assessment Program (EMAP), MMS's Gulf of Mexico Region, Florida Department of Wildlife Service's Panama City Ecological Services Office, NPS's Gulf Island National Seashore, University of South Alabama's Dauphin Island Sea Lab, the National Marine Fisheries Service, and the University of Southern Mississippi's Gulf Coast Research Lab.

Contaminants

Contaminant research and monitoring is directed at understanding how contaminants, such as pesticides, industrial chemicals, excessive nutrients, algal toxins, and trace elements, affect organisms, populations, and ecosystems. Information generated by contaminant research and monitoring is provided to regulators, and land and resource managers to help minimize impacts of contaminants on biological resources. USGS scientists integrate the principles of environmental toxicology and chemistry with those of ecology and conservation biology to comprehensively address contaminant issues of importance to the DOI.

Biomonitoring of Environmental Status and Trends (BEST) — The BEST Program monitors, identifies, and assesses the effects of environmental contaminants on the Nation's biological resources, particularly those under the stewardship of the DOI, in order to provide scientific information for guiding management actions. To accomplish this goal, BEST integrates field and retrospective monitoring, synthesis, applied research, and technical assistance. For all these components, impacts of environmental contaminants on biological resources are evaluated through the application of multiple lines of evidence that include

measures of both exposure and effect. Monitoring provides natural resource managers with comparisons of broad geographic areas for evaluating the relative threats of contaminants to biological resources across the U.S., benchmark databases for interpreting the results of site-specific investigations, and pictures of temporal patterns for assessing changes in exposures and effects (See <http://www.best.usgs.gov/>).

Field monitoring has focused on the Mississippi, Rio Grande, and Columbia river basins, but work is continuing on developing approaches for DOI lands and key habitats of species under DOI stewardship. Retrospective monitoring has focused on the Atlantic Coast (see box) and is being expanded to the Pacific and Gulf Coasts due to its success at compiling existing data in an easily accessible format for natural resource managers, at identifying data gaps, and at describing temporal patterns. Synthesis has focused on describing the state of knowledge on topics such as effects levels for biomarkers, wildlife species suitable for regional contaminant monitoring and ecological risk assessment in estuaries, reporting of mortality incidents, and contaminant threats in the lower Rio Grande Valley. Under applied research, the development and testing of biomonitoring methods and assessment tools continues at USGS Science Centers. BEST also provides technical assistance, including training, technical guidance, and decision-support tools, to the FWS and other DOI Bureaus for assessing contaminant threats to refuges, parks and other DOI lands.

Environmental Toxicological Research — Research includes controlled laboratory and field studies and is directed at understanding modes of action of environmental contaminants; describing the relative toxicities of individual and mixtures of chemicals to a variety of species;

developing and validating bioindicators of exposure and effect; delineation of exposure pathways; evaluating cause-and-effect linkages between contaminant stressors and observed impacts; and developing models for prediction.

Currently, USGS scientists at the Columbia Environmental Research Center (CERC) are assessing the effects of endocrine disrupting contaminants on reproductive development and behavior, sexual differentiation, and biochemical changes in fish. The interaction of chemical contaminants and nutrient deficiency is also under study, in particular, as it relates to early mortality syndrome in salmonids from the Great Lakes. Other research, at the Florida Caribbean Science Center is indicating dietary exposure to methyl mercury negatively affects reproduction and endocrine function in large-mouth bass, and freshwater mussels. USGS scientists are collaborating with BOR managers to understand complex interactions among contaminants, nutrients, habitat suitability, and physical

characteristics within western reservoirs. CERC, Midcontinent Ecological Science Center (MESC) and Leetown Science Center scientists continue to evaluate effects of past mining practices on terrestrial and aquatic resources. Current studies associated with this DOI and USDA Abandoned Mine Lands Initiative are focusing on development of strategies to assist federal land management agencies in formulation of effective remediation alternatives.

Role of contaminants in amphibian deformation and decline

The high incidence of physical deformities in frogs and the widespread decline in frog populations are of great concern. Elevated frequencies of frog deformities in several parts of North America were linked to pesticides, but no cause and effect relationships have been shown. Controlled experiments to test the effects of mosquito-control compounds on malformations and population size were conducted at the USGS Patuxent Wildlife Research Center. Results indicated that Abate, with the active ingredient temephos, significantly decreased the abundance of several frog species when applied to wetlands in accordance with label directions. The research also showed that wetlands sprayed with Altosid, with the active ingredient methoprene, had a higher frequency of deformed southern leopard frogs than did control wetlands.

Recent Accomplishments

Aquatic Injury Assessment: Effects of Metals Associated with Mining Waste in Sediments, Biofilm, Benthic Macroinvertebrates, and Fish from the Coeur d'Alene River Basin, Idaho

— A multi-year evaluation of the effects of historic mining activity in the Coeur d'Alene basin documented pathways of contaminant exposure resulting in adverse biological impacts. Concentrations of arsenic, cadmium, copper, lead, and zinc in aquatic invertebrates and fish were 2 to 14 times greater than concentrations found in less contaminated tributaries. In addition, studies demonstrated that wild populations of adult chinook salmon, during spawning migration, avoided metals-contaminated tributaries of the Coeur d'Alene River. This work falls under the auspices of the DOI Natural Resources Damage Assessment and Restoration program.

Innovative Method for Assessing Air Quality — USGS has expanded the use of the semipermeable membrane device (SPMD) to monitor air quality and to collect environmentally relevant samples for evaluating the toxicity of chemical transported via aerial deposition. Studies have included the characterization of indoor sampling rates of the SPMDs for selected organochlorine chemicals. These devices offer a scientifically valid and cost-effective methods

to assess air quality, identify sources of aerial contamination, and determine potential biological effects associated with degraded air quality.

Effects of Environmental Contaminants on Reproductive Success of Freshwater Mussels

— Research indicates greatly decreased survivorship for juvenile unionid mussels, following their early life parasitic stage exposures to contaminants found in host fish. This contaminant/fish/mussel relationship finding is particularly significant because nearly 70 percent of the 300 unionid mussel species in North America are considered endangered, threatened or of special concern.

Discovery of Lead Toxicosis as a Factor Limiting the Recovery of Spectacled Eiders in Alaska

— The Spectacled Eider is a marine duck that nests in tundra habitats in western and northern Alaska and arctic Russia. The population nesting on the remote and roadless Yukon-Kuskokwim (Y-K) Delta in western Alaska declined nearly 97 percent from 50,000 pairs in 1971 to about 1,700 pairs in 1992. The cause for this significant and sustained decline were unknown. In 1998, sampling of Spectacled Eiders for evidence of exposure to lead was expanded to include important nesting and brood-rearing habitats on the Y-K Delta. Blood samples were analyzed for lead, and birds were examined in the field with a portable x-ray machine to identify ingested shot. During the brood rearing period, 35.8 percent of adult females and 12.2 percent of ducklings were exposed to lead when captured. The USGS-ABSC developed models to assess the probability of exposure to lead in relation to date of capture of females. This analysis predicted that 50 percent of the successful breeding hens, and 25-35 percent of the breeding females in one subpopulation on the Y-K Delta was exposed to lead. Further, USGS-ABSC studies demonstrated that exposure to lead lowers the annual female survival rate by 34 percent. The information from this USGS-ABSC work will be used by managers in developing recovery plans and in potential delisting decisions under the Endangered Species Act.

Fisheries and Aquatic Resources

Research conducted in the Fisheries and Aquatic Resources program area centers on determination of factors affecting the reproduction, survival and health of fish and other native aquatic fauna including their physiology, behavior, genetics and habitat requirements. The USGS develops and evaluates methods for restoring and managing populations and communities through culture techniques, artificial propagation, and the diagnosis and treatment of disease. Scientists determine the systematics, taxonomy and distribution of species of concern, including identification of populations and their taxonomic relationships, habitat characteristics, resource needs, and the biological integrity of multi-jurisdictional aquatic systems, including the effects and mitigation of habitat alterations on riverine species.

Fish Passage — The USGS maintains a unique environmental laboratory designed to test structures that allow fish to by-pass dams or other obstructions. Dams limit access to spawning grounds which affects the long term survival of migratory species. The Silvio Conte Anadromous Fish Laboratory, located on the Connecticut River, develops information on behavioral, physiological, and hydraulic phenomena that determine the success of artificial structures intended to allow fish to pass around river obstacles. Research leads to restoration and enhancement of anadromous fishes such as Atlantic salmon, American shad, river

herring, American eel, shortnose and Atlantic sturgeon, species of concern to Federal and state agencies. In FY 1999, USGS scientists enhanced efforts for effective fish passage in rivers affected by hydropower structures, providing data for the FERC re-licensing process of dams on over 300 sites in the Midwest and Northeast, and assisting managers in conservation planning and restoration of threatened and endangered fish. The focus is on migratory species.

Coastal Fisheries — Coastal fishery studies encompass important species on all coasts. Halibut in Glacier Bay, important fishes of San Francisco Bay, and small California estuaries are targets on the West coast. As techniques improve, populations of Florida coastal species and Atlantic striped bass can be estimated more effectively for evaluating management strategies. Work on striped bass restoration includes improving marking methods and developing cost-effective culture techniques. Efforts are underway to better understand food webs of native fishes and relationships among invertebrate fauna.

Fish Biology — The USGS fishery research program examines all phases of the life cycles of fish and their habitat requirements. Work on salmon looks at critical processes in the transition from fresh to salt water, the ability of fish to identify home streams, and relates findings to improved restoration techniques. Understanding the habitat requirements of salmon in Alaska and effects of hatchery supplementation on wild stocks helps to enhance fish productivity and preserve diversity. Research on imperiled fishes focuses on interactions with non-native species while limnological studies examine changes in water quality associated with land-use, diversion, and impoundment of streams. Techniques are being developed to better manage reservoirs and river systems such as the Missouri, Mississippi, and Colorado rivers, which are characterized by changing reservoir habitats.

Fish Genetics — Studies in fish genetics characterize variability and taxonomic status of individuals, stocks, races, and populations. Assessed information can be used to help manage harvest and determine restoration strategies. Efforts underway include identifying genetic traits for restoration of Atlantic and Pacific salmon and lake trout, cataloging genetic attributes of hatchery stocks of fish, and genetic identification of salmon in Alaska to improve stock management. Genetic information can also be used to determine the type and sometimes the source of caught fish and to settle stock allocation disputes.

Genetics of Atlantic salmon unraveled

Scientists from Leetown Science Center have completed a state-of-the-art-study for the definitive analysis of Atlantic salmon population structure. These data are being used in mixed stock analysis, manipulation of genetic variability in managed broodstock, gene marking to identify tributary of origin, hatchery product evaluation, assessment of life history characteristics such as movement, reproductive success, and kinship, and testing classical theoretical models of the interactions between environment and genetic variability. This use of DNA variation has also shed new light on the population structure among North American salmon and has been heralded as a major contributing factor in the decision not to list Atlantic salmon populations under the Endangered Species Act.

Fish Disease — Fish disease research focuses on development of better methods for detection of causative agents and improved diagnosis of disease, enhanced understanding of epizootiology, and development of methods to control losses from fish diseases. Fish disease research supports the National Fish Hatchery System and all forms of public aquaculture through improved treatments and technologies to maximize fish production, often a critical component of aquatic system restoration. Disease in wild populations is also a target of investigations with active work in the Chesapeake Bay, Salton Sea, northeast Atlantic Salmon, the herring fishery in Prince William Sound, Alaska, and in western rivers affected by whirling disease.

Fungus causing fish lesions in Chesapeake Bay

In FY 1999, USGS scientists investigated the cause(s) of fish lesions and their relationship to *Pfiesteria* so that resource managers can evaluate solutions to potential causative agents. USGS scientists reported that many of the fish lesions in Chesapeake Bay may be caused by a fungal infection rather than by the toxic dinoflagellate, *Pfiesteria*. While *Pfiesteria* remains the primary cause of fish kills in the Chesapeake, North Carolina, and other estuaries, a fungus seems to be responsible for lesions in menhaden fish of the Chesapeake Bay. Scientists from the Leetown Science Center found fungal infections in more than 95% of the lesioned menhaden sampled from various river sites in 1997 and 1998. The fungus appears to be similar to one that has caused identical lesions and fish kills of estuarine and freshwater fishes throughout the Indo-Pacific area. Although it is possible that *Pfiesteria* may play a role in the development of fish lesions, USGS research shows that other factors must be considered.

Native Mussels — The USGS is a nationwide leader in research and monitoring of native freshwater mussels. Freshwater mussels are an important, but threatened, component of aquatic ecosystems. Sixty-four species are listed as threatened or endangered under the Endangered Species Act. Recent evaluations of mussel populations indicate that about 75 percent of the 300 species of native mussels in North America are endangered, threatened or of special concern. The factors that make freshwater mussels excellent indicators of water quality--they filter water to obtain food, are long-lived, are relatively sedentary, and have close ecological ties to other aquatic organisms--make them vulnerable to water pollution, sedimentation, and habitat destruction. The introduction of the zebra mussel and other exotic mussels also poses a threat to the continued existence of native mussels. The USGS research and monitoring activities explain how exotic species and environmental degradation of streams, rivers, and lakes are affecting native mussel populations and how at-risk populations can be protected. Techniques are now being used in the field to hold, propagate, relocate, and re-introduce native mussels, and new methods are being developed to determine their distribution and abundance. In FY 1999, USGS scientists are determining the distribution, abundance, and conservation status of at-risk faunal groups, evaluating the habitats of selected endangered or at-risk species to identify changes in habitat quality that may be limiting natural populations of these species, and maintaining a geographically-referenced digital database of aquatic fauna to ensure the transfer of information to Federal, state, and local resource agencies.

Large Rivers — USGS research related to the unique resources and conditions found in America's large rivers, such as the Missouri, Mississippi, and Columbia, is developing vital information on fish community structure and function, habitat restoration, migratory bird habitat, and degree of sediment contamination. Ultrasonic tags are used to monitor and characterize habitat use by endangered fish species such as the pallid sturgeon and paddlefish; other new technologies are employed to determine instream habitats for benthic organisms, fish, and other components of large river ecosystems. The studies are conducted in collaboration with State natural resources agencies that need this information to successfully meet their management responsibilities.

Missouri River environmental assessment program

The Missouri River is over 2,000 miles long and drains one-sixth of the United States. In the past 60 years, over 50% of the river has either been channelized or impounded which has drastically altered the ecosystem. Today, numerous fish and wildlife species are Federally listed as endangered, threatened, or of special concern. As a result of the devastating effects of several major hydrologic events on the Missouri River, such as the drought of 1988-1992 and the flood of 1993, the U.S. Army Corps of Engineers drafted environmental impact statements to change current Missouri River operations. One major outcome of this exercise was the need for comprehensive, long-term natural resource data to understand the effects of any future river management decisions. The Lower Missouri River Ecosystem Initiative (LMREI) facilitated the transfer of information among the various state and federal agencies involved in rehabilitation and management of the Lower Missouri River Basin. Activities of the LMREI include initiating an annual conference on the natural resources of the basin, creating an Internet home page (<http://infolink.cr.usgs.gov>) containing a searchable bibliography, providing spatial information to managers, creating a global positioning system base station in central Missouri, providing technical support to the FWS' Big Muddy National Fish and Wildlife Refuge, completing electronic maps of historical river channels and vegetation, and providing technical support in developing the Missouri River Environmental Assessment Program.

Missouri River Basin Study Area

Missouri River Environmental Assessment Program

It is suspected that the elevated concentrations of nutrients in the Gulf of Mexico, that contribute to extremely low concentrations of oxygen in bottom waters, originates largely from agricultural watersheds in the Upper Mississippi River basin. In FY 1999, the USGS began a new initiative to determine mechanisms to enhance nutrient retention in the Mississippi River basin, thereby reducing downstream transport.

Great Lakes — USGS scientists conduct a regional program of research to develop the knowledge and technical basis for assessing, protecting, and rehabilitating the valuable fishery resources and aquatic habitats in the Great Lakes. The research program includes studies of the biology and dynamics of important sport, food, and forage fish populations, and evaluation of habitat limitations that inhibit successful survival, reproduction, and recruitment of these populations.

Recent Accomplishments

Towboat-Induced Mortality of Large River Fishes — A collaborative research effort led by the Upper Midwest Environmental Sciences Center in La Crosse, WI, and funded by the U.S. Army Corps of Engineers, has developed a method to estimate the number of adult fishes killed, by entrainment through propellers, per kilometer of travel by commercial towboats on the Mississippi and Illinois Rivers. The resulting estimates indicate that towboat-induced mortality may be substantial for gizzard shad, shovelnose sturgeon, and smallmouth buffalo in these

rivers. These data will be used by the FWS and the U.S. Army Corps of Engineers during deliberations on expansion of navigation capacity.

Improved Sampling Techniques for Great Lakes Fishes — USGS scientists completed a five-year study to adapt and refine the use of acoustic technology to enhance the assessment and study of Great Lakes fishes. Use of acoustic sampling techniques, when fully integrated with existing surveys, will greatly enhance sampling and study of Great Lakes fish communities by the USGS and our Federal, state, and tribal partners.

New Detection Method for the Causative Agent of Bacterial Kidney Disease — USGS scientists have developed a nested, polymerase chain reaction detection method for *R. salmoninarum*, the causative agent of bacterial kidney disease, the most significant bacterial pathogen of Pacific salmon. A single bacterium can provide 25 million copies in a few hours. These amplified copies are easily detectable by gel electrophoresis. This new assay is substantially more sensitive than any of the previous techniques and can be used to aid our understanding of the uptake, spread, and elimination of the bacterium in fish, to screen fish carriers and reservoirs of infection, and to study the pathogenesis of this important disease agent. The primers for the test and training in their use have been provided at no charge to fish health workers in state, private, tribal and FWS diagnostic laboratories.

New Genetic Markers Identified in Atlantic Sturgeon — USGS biologists at the Leetown Science Center have developed microsatellite DNA markers in Atlantic sturgeon that have clarified the population structure previously undetected in Atlantic sturgeon. The markers also distinguish the Atlantic and Gulf of Mexico subspecies. These findings have regional and international implications for sturgeon population genetics and systematics and can be used to address basic and applied (e.g., forensic identification of caviar) issues.

Collapse of Herring Fishery in Prince William Sound Related to Viral Infection? — The collapse of the herring fishery in Prince William Sound, Alaska has prompted the Exxon-Valdez Trustee Council to fund research to investigate the effect of oil on the susceptibility of herring to viral hemorrhagic septicemia virus (VHSV) and *Ichthyophonus hoferi*, a fungal infection. USGS' Marrowstone Island seawater containment laboratory, located in Nordland, Washington has been successfully rearing pathogen-free Pacific herring for over a year. Recent research has shown that herring are extremely susceptible to this virus, which suggests that VHSV may be a factor in controlling populations of herring in the Pacific. Subsequent experiments will examine the effect of oil on the immune responses of these fish.

Wildlife

Research conducted in the Wildlife program area focuses on investigations of factors regulating the distribution, abundance, and condition of wildlife populations and communities including their behavior, genetics, and habitat requirements. Studies also evaluate the effects of disease on wildlife populations and communities and the prevention and management of disease in free-ranging biota.

Migratory Game Birds — USGS research on migratory game birds supports the Interior Department's stewardship responsibilities. Much of this work is in cooperation with the FWS

and state fish and wildlife departments that have direct responsibility for managing populations and harvests. The USGS provides information needed to protect and enhance waterfowl and other game bird populations on national wildlife refuges waterfowl production areas, and other wildlife management units. Research on ducks emphasizes important game species, including black ducks in the eastern States, pintails in the central and western States, and mallards nationwide. Investigations of geese and sea ducks emphasize those nesting in the Alaskan Arctic, which have unstable or declining populations. Research on upland migratory game birds, such as woodcock, doves, and certain marsh and shore birds, examines the causes of population declines and identifies habitat management and inventory techniques needed for restoration.

Is habitat fragmentation limiting migratory bird populations? — USGS biologists from the Northern Prairie Wildlife Research Center, North Dakota, are determining the role of habitat fragmentation as a limiting factor on migratory birds. Many Interior agencies, especially the FWS, NPS, BLM, and BIA, have large holdings of grasslands. Many migratory birds are dependent on grasslands, including basin wetlands common in this landscape. Other Federal agencies, notably the U.S. Forest Service, many states, and certain non-government organizations also have an interest in grasslands and a need for avian information. Grasslands are considered one of the Nation's most imperiled ecosystems: many states have lost 95 percent or more, and remaining tracts are often too degraded or fragmented to be viable. Since grassland birds have shown greater population declines than birds associated with any other habitat, concern for this habitat and its fauna is well-placed. Also, because most grasslands are grazed, and some are influenced by other agricultural practices, it is important the effects of those economic practices be understood and, to the extent feasible, be modified to enhance their compatibility with wildlife populations and grassland health. In this way, Department of the Interior and non-Federal land managers, as well as private citizens, will be able to develop specific management action for a host of species, guaranteeing their long-term survival.

Non-Game Birds — USGS research focuses on environmental factors and human influences on productivity and survival in non-game species. Because of increasing urbanization, as well as agricultural and logging practices, many bird populations are threatened and degraded due to fragmenting and degrading habitats. USGS biologists investigate specific habitat requirements of songbirds, seabirds, shore birds, and eagles. Information on habitat needs and the effects of habitat alteration is developed in cooperation with partners to identify management practices most compatible with maintaining bird populations. Recent accomplishments in this area include documentation of the values of various reforestation techniques in providing habitats suitable for non-game birds in southern hardwood forests. Participation in the interagency public/private Partners in Flight program helps focus research on priority needs of managers.

Population trends and distribution of birds in shortgrass prairies — USGS biologists at the Mid-Continent Ecological Science Center in Ft. Collins, Colorado, are investigating why many bird species are declining in shortgrass prairie landscapes. Native birds of grasslands have experienced widespread declines since 1966. Because of the narrow ecological tolerances of environmental change, these species are the ones that may decline to the point of listing under the Endangered Species Act. This research will define population trends and distributional changes in birds of the shortgrass prairie and determine causes of population declines. USGS

biologists will develop techniques to evaluate population stability of these species using genetic science. This program entails a regional landscape investigation of causal mechanisms contributing to the decline of grassland birds, including the implementation of monitoring efforts at national wildlife refuges.

Large Mammals — Large mammals inhabiting Federal lands are a major concern of land managers, particularly when there are conflicts between populations of these animals and humans or human activities. Studies of grizzly bears in western national parks, brown bears in Alaska, black bears in eastern national parks, and wolves in Minnesota and in the Rocky Mountains seek a better understanding of habitat needs and management practices that will reduce conflicts between these animals and humans or livestock. Studies of polar bears define habitat needs, document movement patterns, and assess populations to assist conservation planning. Research on ungulates, hoofed animals such as deer and bison, examines management that may lead to healthier herds and less damage to vegetation in fragile areas, particularly in national parks and areas of high public use.

Arctic Studies — USGS conducts research in the Arctic to help DOI agencies in Alaska meet their resource management responsibilities. These responsibilities include conservation of migratory birds, certain marine mammals, endangered species, anadromous fishes, and all biota inhabiting national wildlife refuges and national parks and preserves. Research addresses the effects of development, disturbance, harvest, and natural cycles on fish and wildlife populations. Other research seeks to develop improved census and survey methods that will better detect trends in populations with the ultimate goal of providing information that will lead to better management decisions and actions to promote conservation of living resources in the vast ecosystems of the Arctic. Fish and wildlife populations in the U.S. Arctic are extensively shared with Canada and Russia, and a portion of the research effort is directed toward treaty and other international requirements to jointly manage resources. Ecological research in Arctic ecosystems is difficult, given the harsh conditions, inaccessible habitats, and wide-ranging movements of Arctic wildlife. New methods of obtaining information, such as advanced technologies, have been developed for research in the Arctic. Satellite-linked biotelemetry and molecular genetics are but two of many new techniques that have been successfully applied to the problems of fish and wildlife conservation in the Arctic.

Wildlife Disease — USGS supports a unique national program dealing with all aspects of wildlife health issues. Headquartered at the National Wildlife Health Center in Madison, Wisconsin, the program provides research and technical support to the FWS, other Federal agencies, and state fish and wildlife agencies. This Center is a source and clearinghouse for critical information needed to prevent the spread of devastating diseases. The USGS research is targeted to developing vaccines, creating faster and more reliable methods of diagnosis, and identifying environmental conditions that make a particular habitat vulnerable to the outbreak of disease. Early detection of low-level mortality,

Methods to control diseases in Colorado River fish and the black-footed ferret

USGS scientists from the National Wildlife Health Center in Madison, Wisconsin, will research introduced wildlife diseases to control the Asian tapeworm parasite in Colorado River fish and the plague disease that has kept the black footed ferret near extinction. Both diseases have delayed endangered species recovery efforts and conservation expensive for all concerned. The research will build on the success of the recent work conducted by the Arizona Game and Fish Department. In the case of the black footed ferret, the research will evaluate potential control methods for plague in prairie dogs, including mass oral vaccination.

such as bald eagles in the Midwest, may result in the identification of serious disease or toxicant problems that can be addressed before losses impact at risk populations.

Understanding the causes of recent wildlife mortalities in the Salton Sea

This research, proposed by biologists from the Western Ecological Science Center in Sacramento, California, is critical to understanding the 1.5 million birds that annually visit the Salton Sea. This environment is an integral part of the Pacific Flyway, providing essential habitat for both resident and migrant species. In addition, numerous species of migratory waterfowl, including four federally-listed Endangered Species, depend upon Salton Sea habitats. Continued habitat degradation will create an ecological catastrophe to migrant and resident birds. Avian die-offs, coupled with continued habitat degradation, have become critical management problems on the lake. Recently, three large die-offs involved almost 200,000 birds representing 66 species. Because 95% of California's wetlands have already been destroyed, including the loss of suitable habitat in the Colorado River Delta area, the Salton Sea has become increasingly important. An understanding of the causes of recent mortalities, as well as basic ecology and population dynamics, requires detailed data on trends and variations. This research is needed by numerous clients including the FWS, BOR, BLM, the Salton Sea Authority, Imperial Irrigation District, Coachella Irrigation District, California Department of Fish and Game, other state agencies such as the California Public Health Department, California State Parks, and the California Regional Water Quality Board.

Population Modeling — Computer simulation models can help wildlife and land managers make difficult decisions and reduce uncertainty. For example, the mallard duck model predicts population growth based on arrival of migrants in the spring, daily survival of hens, initiation of nests, selection of nest sites, and the survival of nests and broods. Adaptive management uses the model outcomes of current management actions to improve predictions and allows resource managers to compare management scenarios and their effects. Economic analysis and risk assessment models predict the consequences of alternative resource development and conservation activities. Other simulation models help to rehabilitate fish stocks and restore water and habitat quality and to predict consequences of environmental change.

Development of an adaptive approach to connect species and habitat management — USGS researchers are conducting population and habitat research to develop an adaptive approach to connect species management (waterfowl populations) to habitat management (wetlands and grasslands). This work supports the adaptive resource management efforts of the FWS's North American Waterfowl and Wetlands Office and the Office of Migratory Bird Management. This project, led by scientists from the Patuxent Wildlife Research Center in Laurel, Maryland, teams state and Federal management biologists with USGS biologists to develop survey, monitoring, evaluation, and management tools needed to scientifically inform management about decisions that can be implemented in a practical way. Aerial surveys conducted by the FWS in the wetlands and grasslands of the Midwest will be enhanced with remotely collected habitat information. Survey and analytical modeling tools will be developed to evaluate the efficacy of the North American Waterfowl and Wetlands Management Plan. Subsequent phases will involve refinement of ground-based habitat/population relationships, expansion to other wetland/waterfowl systems, and extension of the approaches and tools to other species of migratory birds in other habitats, including species-at-risk, endangered species, and migratory birds.

Amphibian Monitoring — USGS scientists are studying factors responsible for apparent declines in populations of amphibians. Most amphibians have life cycles with both aquatic and

terrestrial phases, so a wide variety of factors in both habitats must be considered. The greatest efforts are in the central and western regions where declines appear to be the most severe. An understanding of the ecological requirements of amphibians is needed to assess the impacts and address future changes. In response, USGS scientists are developing quantitative methods for assessing amphibian populations at several geographic scales across the continent. These methods are being field tested by resource managers and can provide techniques to readily gather information on amphibian changes at local, regional and national scales. The research includes a close look at population structure, orientation, effects of drought, metapopulation formation, experimental reintroduction of specific species, and management implications.

Recent Accomplishments

Dynamics of Wolves and Their Prey in Alaska — Management of wolves and their prey is currently a major national conservation issue with recovery of threatened and endangered wolf populations in the western United States. In Alaska, the contentious wolf management debate continues, and Federal land managers have a large role because of subsistence management responsibilities. USGS Alaska Biological Science Center (ABSC) biologists are studying the population dynamics of wolves and their major prey species, caribou and moose. This research has aided managers in understanding fluctuations in wolf and prey populations and in making predictions of future population trends necessary sustainable wolf populations. Scientists from both USGS and the National Park Service published a book in 1998 entitled The Wolves of Denali. This volume is a summary of the most comprehensive study of wolves and includes important information for use by managers, researchers, and students.

Amphibian Mortality and Malformations — USGS continued to investigate infectious diseases and malformations as possible factors contributing to amphibian decline. While there are few scientific reports of amphibian die-offs, five separate, geographically remote amphibian mortality events were investigated during 1998. Viruses were isolated at the National Wildlife Health Center from the tissues of dead frogs and salamanders involved in all five events. Molecular comparison of the viral genetic material revealed that the viruses from the salamanders were similar to each other. The USGS also conducted two major research studies in free living leopard frog populations to identify the stage in the life cycle when the malformations first occur. Examination of more than 200 individuals and 700 tadpoles confirmed that many of the malformations occurred at specific stages in the development of the tadpole. This information will help biologist determine the best times to search for types of agents or environmental factors causing amphibian malformations

Black Bears — USGS scientists at the Leetown Science Center's Appalachian Field Laboratory are currently leading an effort to compare two repatriation techniques for black bears. One involves the translocation of bears during hibernation to suitable den sites at the release area at Big South Fork National River and Recreation Area in Tennessee. The other involves the use of holding pens to acclimate bears captured during summer prior to their release. Eight adult female bears with cubs were moved from their winter dens at Great Smoky Mountains National Part to Big South Fork and another six adult females were trapped and translocated during summer. The winter repatriation technique has been much more successful, with significantly greater fidelity to the release site and lower mortality rates. This

is the first quantitative comparison of the two techniques and it will have wide applicability to other bear repatriation efforts. A translocation program in Louisiana has already used the winter release method based on our recommendations. Approval has been granted by the NPS, the Tennessee Wildlife Resources Agency, and the Kentucky Department of Fish and Wildlife Resources for a three-year continuation of the research.

Methyl Mercury Acts as an Endocrine Disruptor in Wildlife — Previous studies have primarily focused on the fate and transport of mercury in aquatic species, however, sublethal effects have not been documented. Mercury has been routinely listed as a potential endocrine disruptor in wildlife with little or no supporting data. Recent efforts from the research program at the Florida Caribbean Science Center have examined the effects of mercury exposure in fish (Tilapia and largemouth bass) and freshwater mussels. These efforts indicate that dietary exposure to methyl mercury negatively affects reproductive and endocrine function in these species. These results are among the first reports which demonstrate endocrine disrupting effects for mercury exposures in wildlife.

Ecosystems

The objective of studies conducted within the Ecosystem program area of the Biological Research and Monitoring Subactivity is improved knowledge about the complex interactions among the living and abiotic components of the earth's ecosystems. Such interactions include not only the multitude of biogeochemical processes, energy pathways, and other physical and biological interactions that occur within a single habitat or ecosystem, but also interchanges between and among ecosystems. An important focus is an understanding of why the observed heterogeneity of biological communities develops spatially across landscapes and a better understanding of the dynamics of the ecological processes that are involved. Investigations are undertaken to identify, explain, and predict the ecological consequences of short- and long-term environmental changes. Activities include assessing ecosystem vulnerability to adverse effects of environmental change and providing the information needed to adapt to and mitigate these effects. Examples of Ecosystem projects include the ecology of wetlands, forests, and grasslands; landscape ecology; modeling ecological systems; ecosystem restoration; fire ecology; and global change.

Conservation of Hawaiian Island Ecosystems

Scientists from the Pacific Island Ecosystems Research Center have begun exciting research designed to answer applied landscape-scale questions with the ultimate goal of helping Hawaiian and DOI management agencies conserve large native ecosystems. In Hawaii, the only state with significant areas of tropical forests and with a unique biota which is largely endemic, many native ecosystems have been severely degraded, resulting in the extinction or serious depletion of native species. Two groups of alien predators have had an especially severe effect: small mammals such as rats and mongoose and social insects such as ants and yellow jacket wasps. The goal of the first phase of this program is to develop an integrated adaptive management strategy for the control or seasonal suppression of alien predators in natural areas of Hawaii. The primary product will be a decision support system modeled after successful integrated pest management programs. Control of small mammalian predators is currently the highest research priority in Hawaii for the NPS, which has jurisdiction for protecting and managing natural and cultural resources within the parks they administer. The State of Hawaii and the FWS, with responsibilities for managing endangered species and habitats in the islands, recognize the need for these tools to help manage native ecosystems and prevent the need to add to the roster of Hawaiian endangered species.

Coastal Wetlands/Habitats — The shallow waters and associated wetlands along the coasts are extremely productive, naturally supporting immense populations of wildlife, fish, and shellfish. They are essential habitat for the juvenile life stages of many aquatic species, including recreational and commercially valuable fish species. Other important functions include improving water quality and helping to moderate extreme floods. Losses of coastal wetlands and their associated benefits, including flood protection and nursery habitat for fish and shellfish, have occurred to a significant degree throughout this century. USGS biologists investigate coastal wetlands structure and function, including wetland habitats of the Great Lakes, to assess and predict the effects of human activities and environmental change, to measure the effects of various management policies and actions so that the most effective methods can be implemented, and to develop and test management and restoration tools. Recent studies have developed methods and standards for restoration efforts on San Francisco Bay wetlands. Ecological modeling of wetlands with an emphasis on future predictions; research examining the ecological responses of coastal wetlands to various stressors, including sea-level rise, salinity intrusion, carbon dioxide enrichment, and nutrient and contaminant inputs; studies of non-native species effects and herbivory; and research into effects of physical disturbances such as canal dredging, filling, hurricanes, and floods are ongoing.

USGS biologists have accelerated efforts to develop and test habitat restoration strategies and conduct adaptive management evaluations in a variety of the nations coastal habitats and wetland areas. Specific areas identified as of priority concern to coastal States and DOI bureaus, including the Laguna Madre, Texas; the Atlantic and Gulf coasts of Florida; the San Francisco Bay-Delta; and the Louisiana Gulf coast are among the initially selected areas.

Outer Continental Shelf Environmental Studies — USGS scientists collaborate with the MMS to determine the health and appraise the vulnerability of marine biological communities that could be affected by offshore oil and gas exploration and production. Research includes an evaluation of the long-term effects of offshore oil and gas production platforms in the Santa Maria Basin offshore California, a study of the ecological role of natural reefs and the function of oil and gas production platforms for rocky reef fish assemblages in southern California, an evaluation of the ecological significance of the oil and gas structures of the Gulf, an

assessment of the abundance and distribution of whales and dolphins in the northern Gulf of Mexico, and baseline studies in Alaska areas with oil and gas potential of sea and coastal bird populations.

Coral Reefs — Among the most diverse and biologically complex ecosystems on earth, coral reefs and associated marine habitats appear to be in worldwide decline and the causes are poorly understood. USGS biologists conduct long-term, integrated research on coral reefs and related ecosystems in Florida, the Caribbean, and Hawaii. Specific activities include investigating Hawaiian reef habitats and associated fish populations; studying Caribbean-wide outbreaks of coral diseases; investigating water quality effects on algal blooms and coral reefs; evaluating relationships between salinity and the ecology of sea grasses in Florida Bay; following the recovery of mangrove forests after Hurricane Andrew in Everglades and Biscayne National Parks; and investigating the ecology, community structure and dynamics of reef fishes as an aid for managing valuable but declining fisheries throughout the tropics.

Range and Grasslands — Studies at various scales on native grasslands and managed rangelands are conducted to evaluate range conditions, determine rare plant patterns, appraise species richness, and identify concentrations of native plant diversity. These studies provide managers with baseline information and are the basis for techniques to detect human-induced stress in natural biological communities and for developing management actions for restoring and maintaining the productivity of rangeland ecosystems. Ecosystems with shortgrass steppe, mixed grass prairie, northern mixed prairie, and tallgrass prairie, primarily found in the Intermountain West, are focal points of the majority of this research.

The Role of Fire in Structuring Oak Savannas and Prairies — USGS scientists at the Great Lakes Science Center in Ann Arbor, Michigan, will investigate the role of fire in oak savannas and prairies. Fire is a potent ecological process in the midwest. Fire suppression has destroyed or altered savanna and prairie remnants. Fire has been used as a tool to restore degraded communities, but much of the prescribed burning occurs in the early spring and late fall. Historical records suggest, however, that growing season fires from lightning strikes and human origin have been frequent. Although high fire frequency is known to favor the true prairie flora in savannas and fire season influences prairie composition, the timing of fires in savannas and prairies are not understood. In addition, many managers are reluctant to have such research done on remnant prairies because of their small area and sensitivity. Certain federal lands are, therefore, important laboratories for documenting fire season effects in these rarest of habitats. The effects of releasing “hidden” native plants will be evaluated and historic data will be used to measure the likelihood of natural fires.

Deserts and Arid Lands — In the southwestern U.S. over the past century, an invasion of shrubs such as creosote bush and mesquite have impacted large expanses of semi-arid grasslands naturally supporting a complex mix of plant and animal communities. Livestock and native animal grazing, recreational activities, agricultural use, and other management practices have also affected these communities. Studies are being conducted into effects such as decreased nutritional content of plants, lower diversity of native species or decreased productivity, decreased water availability, diminished soil microbial populations, and accelerated rates of soil surface erosion. USGS investigations are providing land managers with information needed to protect and manage less impacted arid ecosystems; to restore

ecosystems altered by human activity; and to increase productivity on heavily used and intensively managed lands.

Prairie Wetlands — In the Great Plains, the northern prairie pothole region is the principal breeding ground for waterfowl and other waterbirds and serves as the key staging area for arctic and subarctic-nesting waterfowl, sandhill cranes, and shorebirds. USGS scientists are evaluating the current status of prairie wetland ecosystems, investigating factors influencing wetland use by birds, amphibians, and aquatic macroinvertebrates, and quantifying characteristics of restored wetlands. Because most of the prairie pothole wetlands are embedded within agricultural landscapes which are characterized by highly fragmented grassland habitats, much of the ongoing USGS biological research on this region is focused on landscape patterns. The interactions of wetland biota with the hydrology, geochemistry, and sediments of prairie wetlands are assessed at basin and landscape scales. USGS biologists are evaluating how the pattern of grasslands in the landscape affect the nesting success of grassland birds, including upland nesting waterfowl, and how predators use grassland in a fragmented landscape. USGS scientists are also coordinating a multi-agency evaluation of wetland restorations which have been done throughout the U.S. portion of the prairie pothole region.

Forested Wetlands — A variety of forest wetland types, sometimes extending over extensive local areas, are found from Virginia into southeastern Texas. Examples include bottomland hardwoods, bald cypress-tupelo swamps, pocosins, scrub-shrub swamps, and mangrove forests. Forested wetlands provide wildlife habitat, water quality enhancement, flood abatement, timber production, and areas for outdoor recreational activities. Forested wetlands are the most rapidly declining wetland type in North America yet the U.S. Forest Service projects that the demand for their hardwood will continue to rise at the same time that demands for recreational use and wildlife habitat are increasing. USGS scientists are providing technical information needed to restore forested wetlands and manage their flora and fauna, including both economically valuable species and species at risk.

The USGS National Wetlands Research Center has updated and expanded the “Bottomland Hardwood Restoration Manual,” an extremely popular reference. The updated manual covers many aspects of forested wetland restoration in the Southeastern United States including site selection, project planning, site preparation, seeds, seedlings, planting procedures, monitoring, weed control, and biodiversity enhancement. Pre-publication interest in the manual indicates it may well become the bible of restoration. A related article, written with USGS partners, for the first time quantitatively defines old-growth characteristics for this important forested ecosystem. The paper synthesizes data from several field surveys conducted during the 1920's and 1930's in large stands of old-growth bottomland hardwoods; no stands of virgin or even old mature forest remain in this region. Potential users include the FWS and the Louisiana Wetland Management District which is using the information to select species for reforestation projects.

Global Change — Biologists of the USGS participate actively in the U.S. Global Change Research Program and conduct ecological research which is coordinated with research in various other Federal agencies. This research targets: (1) determining the sensitivity and response of ecosystems and ecological processes to climate and other environmental factors at the local, landscape, and regional levels, (2) predicting how future global change and other environmental factors may affect the structure, function, and viability of natural systems, and (3) assessing the implications of change for future management of natural resources. USGS scientists are studying how a long-term change in climate in the western U.S. may shift the competitive balance among plant species, with a warmer climate encouraging the growth of more drought-tolerant conifers and weedy species and enhancing the spread of certain exotic species on DOI lands. USGS long-term monitoring data from several Northwestern parks, including North Cascades National Park, which contains over half of the glaciers in the continental U.S., and Glacier National Park, show that glaciers have retreated significantly during the warmer climate of the twentieth century. Information developed in this program will be used in the National Assessment of the Impacts and Consequences of Climate Change in the U.S. and by DOI land managers.

Air quality monitoring in the Cascade Mountains of Washington.

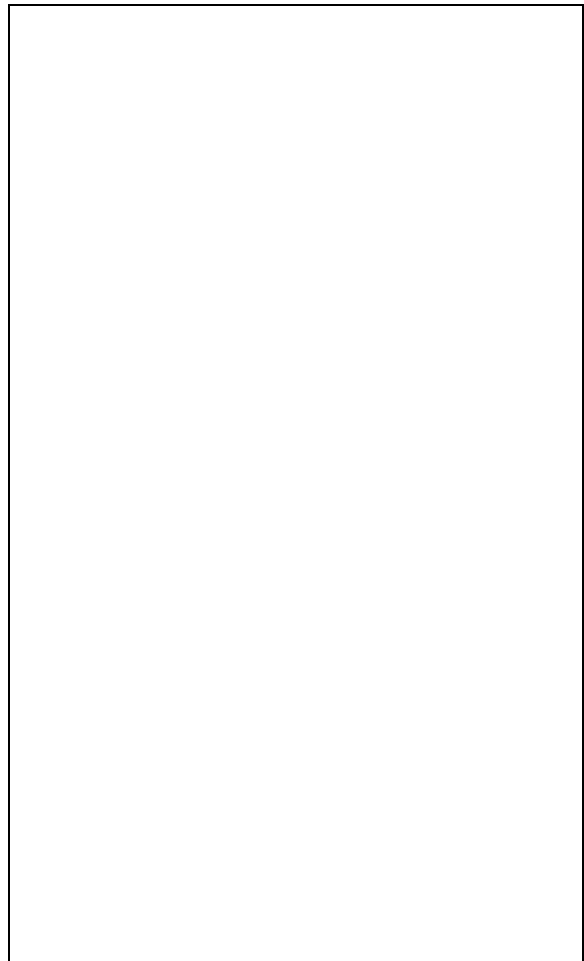
Recent Accomplishments

Wetland Restoration Success Documented — The USGS National Wetlands Research Center and the Louisiana Department of Natural Resources documented the success of two projects under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Using advanced geographic information system techniques to compare pre- and post-construction data, USGS showed that over two years the Bayou LaBranche project gained 275 acres of vegetation that had previously been water, the greatest percent gain of any CWPPRA project to date. Additionally, for a Bayou Sauvage National Wildlife Refuge project under CWPPRA, USGS and the State demonstrated a gain of 327 acres of freshwater marsh from

1994 to 1996. As reported by refuge biologists, this gain in freshwater marsh correlates with an increase in pintail ducks in the restoration area from 800 in 1994 to 2,875 in 1996.

Rapid Landscape Response to Climate

Variation Documented — USGS Midcontinent Ecological Science Center scientists extended the body of climate change research by reporting the fastest climate-induced, landscape scale boundary shift between two ecosystems ever documented. Conducted in cooperation with the Los Alamos National Laboratory, the research demonstrated how rapidly vegetation can respond to climate and has significant implications both for modeling how climate can decimate vegetation during droughts and for assessing the potential impacts of global climate change. While previous studies have focused on birth and growth of vegetation and have documented shifts taking place over decades or centuries, this research documented a change that occurred in less than five years and emphasizes that attention should be focused on mortality because the rapidity of the shift resulted from the death of vegetation as a result of drought. The observations provide an improved understanding of interactions between plants and climate variability and could help scientists more accurately model what will happen in semiarid ecosystems when climate changes globally.

**Killer Whale Predation on Sea Otters Links**

Oceanic and Near Shore Ecosystems — USGS biologists at the Western Ecological Research Center reported sharp reductions in sea otter numbers around the North Pacific rim. In an article in *Science*, they explain how sea otters in western Alaska waters are disappearing due to killer whale predation. This highly unusual behavior of killer whales toward sea otters raises serious questions about the health of the oceans because of the respective roles of sea otters and killer whales in their food webs. A keystone species of coastal ecosystems, the sea otter is an animal on which the balance of entire ecosystems rests. Without sea otters as predators, sea urchins increase in numbers and devour coastal kelp forests. This finding has heightened research interest and may provide future opportunities for improving near shore ecosystem management in the "Year of the Oceans."

Ecological Status of the Upper Mississippi River — The Upper Midwest Environmental Sciences Center completed a scientifically based summary of the ecological status of the Upper Mississippi River System. USGS scientists synthesized work accomplished and data collected from 1987 through 1997 under the congressionally authorized Upper Mississippi River System Long Term Resource Monitoring Program. The assessment introduces six

criteria for gauging river ecological health, and applies these six criteria to several floodplain river reaches along the 1300 mile Upper Mississippi River System. It is targeted for use by river managers, policy makers, the general public, and scientists so they can better understand the ecology and health of the Upper Mississippi River ecosystem. The report will provide information useful to State, Federal, and tribal governments planning bicentennial celebrations and events to commemorate the Lewis and Clark expedition and to communities along the Upper Mississippi River that are involved in the American Heritage Rivers Program.

Application of Science Information to Management

This program area develops and advances scientific tools that apply ecological and other information to the management of biological systems, often in collaboration with natural resources agencies. Development of models and support systems assists decision-making in such areas as land-use planning, land and water management, timber harvest, wetland management, fish and wildlife management, endangered species policies, urban development, and other areas involving human interactions with biological resources. These tools incorporate the best available economic, social, and ecological science information to offer alternative ways to balance social and economic needs with natural resource management and conservation. Examples of these efforts include the Upper Mississippi River Decision Support System, VegSpec-Revegetation Tool, Socioeconomic Evaluation of the Conservation Reserve Program, and Across Trophic Level System Simulation System.

Predictive Population Modeling — Effective natural resources management requires an ability to predict the consequences of both natural and human-caused environmental changes to populations of plants and animals. Through development of predictive population models, this program assists resource managers in making difficult decisions by reducing the uncertainty associated with population responses to habitat and environmental change. For example, the “mallard model” uses such information as date of spring arrival, survival of hens, habitat characteristics, and survival of eggs and broods, to predict annual recruitment of mallards into regional populations. This, in turn, allows waterfowl managers to establish sound harvest limits and adjust habitat management practices to optimize annual mallard productivity. Other models help predict fish population responses to aquatic perturbations in an effort to restore fish stocks and the water and habitat conditions upon which those populations depend. Economic analysis and risk assessment models help predict the consequences of alternative resource use and conservation activities.

Science for Decision Support Systems — The gap between scientific information and management decision-making can be pronounced. Decision support systems bridge that gap by creating strong linkages between information and management, thereby placing resource-based decisions in the context of the best available information. This program develops and advances the science associated with decision support systems, thereby ensuring incorporation of the most rigorous scientific information available. Examples of such systems include development of strategies for monitoring surface waters in coastal states, resolution of potential oyster leasing conflicts in Louisiana, development of adaptive harvest guidelines for North American waterfowl populations, and identification of potential habitat for enrollment in the voluntary Wetland Reserve Program.

State Partnerships — This program promotes collaborative projects between State and Tribal institutions and USGS field units that address high priority conservation and management issues. Projects focus on providing scientific information needed to develop habitat and ecosystem restoration plans, and on enhancing the accessibility of scientific data and information products to State and Tribal land managers. Results of projects completed through this program are used by other State, Tribal, and Federal natural resource agencies to guide future management actions.

Human Dimensions and Socioeconomics — Ecosystem management requires a firm understanding of biological, as well as economic and social, issues and processes. Interaction between human communities and their natural surroundings through consumptive and non-consumptive activities can introduce various changes and stressors to ecosystems. Human dimensions-social valuation studies are used to better understand those human-induced changes, determine the environmental conditions desired by local communities and users of natural resources, and develop information that assists decision-makers in sustaining or restoring healthy ecosystems. For example, because of rapid and extensive changes in the Colorado Plateau region, a human dimensions-social valuation study is needed to identify obstacles and opportunities for sustaining both ecosystems and human communities. The objectives of this USGS institutional analysis study is to: (1) prepare a GIS representation of the Colorado Plateau to assess how overlapping jurisdictions affect implementation of public land management policies with respect to recreational opportunities, and (2) evaluate the individual awareness of local residents regarding recreation policy on public lands. The results of the study will be used by federal lands managers in the NPS, BLM, and U.S. Forest Service, to design effective recreation management policies that are understandable, scientifically sound, and meet the needs and expectations of the public.

Pacific Northwest Forest Plan — The President's Pacific Northwest Forest Plan calls for major changes in the management of Pacific Northwest forests on Federal lands to ensure that species associated with old-growth and riparian areas have suitable habitat throughout their ranges. USGS research is identifying the essential habitats and specific life history requirements of sensitive species required to implement the Plan. Projects are directed toward assisting other agencies with implementing required monitoring and coordinating development of effective monitoring tools for aquatic and riparian ecosystems and for forest biodiversity.

Recent Accomplishments

Vegetation Restoration — VegSpec (beta version 2.0) is a decision-support tool that allows public and private land managers to make informed decisions about appropriate species and techniques to establish plants for specific purposes, such as rangeland cover, erosion control, and windbreaks. This expert system, developed cooperatively with USDA-Natural Resources Conservation Service and the U.S. Army Construction Engineering Research Laboratories, assists with decision-making by querying scientific data on soil type, climate, and physical and physiological characteristics of more than 2000 species of plants. The user-friendly software automates the selection of plants species based on site-specific conditions, and assists in the design and application of practices for establishment of wildland vegetation throughout the United States. Version 2.0 represents a major refinement of a text-based version with a new graphical user interface. It also allows for efficient web-based access using current browser

software. VegSpec saves natural resource managers time and money by providing all relevant information necessary for developing a planting design tailored specifically for the site in question.

Decision Support System for Oyster Production Leasing in Restoration Areas — The USGS has developed a system to assist the Louisiana Department of Natural Resources (LDNR) and the Coastal Wetland Planning Protection and Restoration Act Task Force (Task Force) in evaluating potential oyster leasing conflicts related to coastal restoration. The Task Force and the LDNR are involved in long-term efforts to restore Louisiana's coastal wetlands. Many restoration projects are in oyster-producing waters, requiring planning to evaluate the impacts of new leases within potential restoration areas. State water bottoms are leased by the Louisiana Department of Wildlife and Fisheries (LDWF). Lawsuits, totaling hundreds of millions of dollars, have been filed against LDNR and LDWF related to the alleged detrimental impacts of restoration projects. The decision support-GIS system developed by the USGS with LDNR and the Task Force is being used in the courtroom by attorneys for the State. A USGS researcher serves as an expert witness and data manager for the decision support GIS in the court room.

Missouri Resource Assessment Partnership (MoRAP) — Obtaining high quality scientific information in a timely manner is imperative for effective management of natural resources. This cooperative State and Federal initiative develops natural resources information and disseminates it at low cost to management agencies, which then can make decisions in the context of sound scientific information. The benefits of this state-of-the-art program have proven to be diverse and timely. In aquatic systems, MoRAP is focusing on characterizing the distribution of aquatic organisms, including fish, mussels, crayfish, and snails, and digitizing the stream networks of Missouri at a scale that will immediately assist agencies and local planning commissions. In terrestrial ecosystems, the Partnership is classifying, mapping, and digitizing land cover and soil types to aid in natural resources and land use planning. Through a truly unique project, MoRAP is reconstructing maps of the types and distribution of vegetation that existed in Missouri before European settlement as part of an initiative to establish sensible conservation priorities. Taken together, these and other MoRAP projects are allowing local, State, Federal natural resource stewards and land use planners to better manage natural, cultural, and biological resources in Missouri.

Endangered and At-Risk Species

Reversing the rapid loss of biological diversity remains the greatest challenge to natural resource managers. Reasons for species' decline include habitat loss from development, agriculture, road building, reservoirs, and mining operations; habitat degradation from fire suppression, livestock grazing, damming and other changes in the amount and quality of water, and invasions of exotic species; and health effects such as disease and contaminants. Restoring declining populations thus depends on an integrated program of research to develop critical information on the biology of individual species and the ecological relationships between those species and their habitats. Through improved data collection and analysis focused on linking physical, chemical and biological factors with others contributing to alterations in species composition and health, the USGS is providing land and resource managers with additional tools for addressing these issues.

Endangered and At Risk Species research focuses on determining the status and trends of rare species; detecting the point at which species fall into the status of being at risk; identifying factors responsible for the decline of threatened and endangered species; and assisting in the development of management plans and methods to restore depleted populations and to prevent further declines. Most USGS endangered species research supports recovery of species already having legal status under the Endangered Species Act of 1973, as amended. To help managers achieve the goals of recovery plans, USGS scientists investigate the life requirements of listed species and factors limiting their populations. Better knowledge of both requirements and limitations is needed for managers to act effectively to promote restoration of populations.

Endangered Species — USGS endangered species research provides the biological information needed to restore currently listed populations, to support de-listing wherever possible, or to preclude future listings by clarifying species' status or suggesting timely preventative actions. Completed efforts on whooping and Mississippi sandhill cranes, Puerto Rican parrots, masked bobwhite quail, and several other species have led to effective management prescriptions now transferred to resource managers. Ongoing research on the grizzly bear, Hawaiian forest birds, black-footed ferrets, the West Indian manatee, southern sea otters, Mexican and northern spotted owls, sea turtles, desert tortoises, and the gray wolf continues to examine limiting factors, and to give Federal, State, and private-sector managers more effective tools to restore populations.

USGS scientists are also involved in efforts to conserve species before they become listed, thereby avoiding associated constraints and conflicts. Projects involving population viability analyses and investigations of factors causing the decline of species generate new information to support species protection and restoration efforts.

Sea Turtles Return to Padre Island

USGS biologists, working with the NPS, have successfully established a second nesting site for the endangered Kemp's ridley sea turtle at Padre Island National Seashore (PAIS), Texas. Until recently the only known nesting location for this turtle was on the Gulf Coast of Mexico. In 1998, there were 13 confirmed sea turtles nesting on the Texas coast, a 30% increase from 1997. Three turtles were confirmed as returnees from the 1978-1988 experimental transplant program at PAIS of eggs from Mexico. USGS scientists tagged 4 of the 1998 nesting females with satellite transmitters to learn more about their movements and habitat requirements. Tracking results documented that these turtles remained very close to the shoreline after nesting and moved long distances along the Gulf Coast as far away as Florida. This movement information has already been used by management agencies in their efforts to protect this species. Sea turtle research remains critical in developing successful resource management strategies for the conservation of this most rare of all sea turtles.

The USGS also supports Habitat Conservation Planning. Ongoing work relates to protection and restoration of the California gnatcatcher (part of the Natural Community Conservation Planning Program), the giant garter snake, and the Karner blue butterfly. Each of these species was only the first in their respective habitats believed to require additional protection. The key to protecting both species and preventing the listing of additional species occupying the same habitats is habitat conservation planning. Plans undertaken early enough and broadly enough can achieve species protection and allow reasonable economic development.

Biological Research and Monitoring Subactivity

In partnership with DOI resource management bureaus and with State and local governments, USGS scientists are providing the kinds of sophisticated technical knowledge required to develop and implement effective habitat conservation plans.

Adaptive Management — In support of the Coastal Sage Scrub Natural Community Conservation Planning (NCCP) Program in Southern California, USGS biologists at the Western Ecological Research Center are conducting an analysis of existing monitoring efforts and developing a comprehensive ecological monitoring strategy. This effort is determining if the ecological system within the 6,000 square mile NCCP planning area is functioning effectively and is self sustaining. The development of a region-wide ecological monitoring strategy will further refine existing biological monitoring plans and ensure consistency among regions. Data collection for management agencies within the NCCP planning area will be more effective and efficient. The effort will be executed through an existing interagency team under the guidance of the Western Ecological Research Center. The team includes the primary regulatory agencies, FWS, California Department of Fish and Game, as well as other involved Federal, state and local partners.

Also in California, an evaluation of past uses and an update of current desert tortoise demographic data is underway by USGS scientists at the Western Ecological Research Center. Of use to FWS, BLM, NPS, DOD, California Department of Fish and Game, California Energy Commission, and nonprofit organizations (land-based conservancies), these data are used to develop habitat conservation plans and Section 7 Consultations.

Restoration of Imperiled Fishes in Southwest Arid Ecosystems — Research in support of restoration of imperiled fishes on Federal lands in the Southwest is underway by USGS biologists at the Western Fisheries Research Center. As Federal lands in the desert Southwest provide habitats critical for recovery of listed aquatic species, current research at the Ash Meadows NWR is being extended to other imperiled Southwest fishes affected by forest practices, contaminants, or problems resulting from grazing practices. A new heat-shock gene expression assay will be tested as part of a decision support system for use by FWS, NPS, BLM, and State resource agencies for management of desert fishes.

USGS scientists at the Forest and Rangeland Ecosystems Science Center are conducting research investigating the relationships of riparian habitats to sensitive and endangered birds in the Southwest, with special emphasis on willow flycatchers, neotropical migrants, and Mexican spotted owl. Important information for riparian restoration will result from this investigation conducted along the Colorado River corridor, within riparian habitats of the southern Colorado plateau, and along other rivers and streams of the Southwest, including parts of Arizona, New Mexico, and Utah. Much of the work will be done at NWR, NP, BLM and state (Arizona and New Mexico) lands.

Recent Accomplishments

Karner Blue Butterfly (*Lycaeides melissa samuelis*) — USGS researchers at the Great Lakes Science Center have described the relationship between shading and habitat use by this Federally listed endangered species. Long term changes in shading resulting from fire suppression have been postulated to contribute to the decline of this species. Research results through 1998 show that the species responds to shading in a complex manner. Males avoid shaded areas but females lay a large portion of their eggs in moderately shaded areas. Caterpillars emerging in shaded areas can grow more rapidly than in very open areas. Fire management can effectively restore areas if it produces a heterogeneous landscape of large openings surrounded by areas with moderate density of trees.

Nesting Patterns in Sea Turtles — USGS scientists have completed a three-year effort to evaluate information on nesting trends of five species of sea turtles from six National Seashores and eight states along the Atlantic and Gulf Coast of the United States. Procedures used in sea turtle monitoring efforts were compared and information was summarized. In general, annual fluctuations in nesting activity were similar among states and National Seashores. Primary influences on nesting activity included inundation, erosion, commercial fishing, vehicle use, human disturbance, predation, and artificial lighting. National Seashores included Cape Hatteras, Cape Lookout, Cumberland Island, Canaveral, Gulf Islands, and Padre Island. States included North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas.

Hawaiian Forest Birds — USGS scientists at the Pacific Islands Ecological Research Center have used an experimental approach to investigate the effectiveness of ground-based predator control to protect native birds and other wet forest resources. The five year study has demonstrated that it is possible to safely remove alien mammals from native forests through ground-based efforts in key areas. Management recommendations have been provided for practical aspects such as spacing of traps and bait stations, how best to monitor the effectiveness of predator removal programs, costs and personnel requirements, and optimal timing of predator control efforts. Findings indicate that bird populations do respond positively to predator control. Results of this research have served as a model for ground-based predator control on other state and Federal lands on Oahu, Maui, Kauai, and Hawaii for protection of plants, animals and ecosystems.

Exotic Species

Exotic (also called non-indigenous or alien) plants, animals, and disease organisms cause increasing harm to native species and significant economic losses by reducing productivity and foreclosing opportunities for beneficial uses of forests, croplands, rangelands, and aquatic resources. USGS research fills an important niche in Federal efforts to combat invasive species in natural and semi-natural areas through early detection, monitoring of established populations, improving understanding of the ecology of invaders and factors in the resistance of habitats to invasion, development and testing of alternative management and control approaches, and facilitating the availability and integration of information on invasive species.

Hawaiian Invaders — Hawaii's flora and fauna, which evolved in a high degree of isolation, are unusually susceptible to selective pressures from exotic species. Hawaii has the largest proportion of exotic species of any state. Its ecosystems are especially vulnerable to the introduction and spread of exotic species due to increasing human travel and trade. USGS research focuses on the ecology and control of highly invasive exotic plants (e.g., miconia, faya tree, strawberry guava, Kahili ginger), including exploration and testing for biological control agents; animals (e.g., Argentine ant, yellow jackets, brown tree snake on Guam); and wildlife disease organisms, and methods for reducing the impacts of invasive exotic species on the region's unique native flora and fauna.

Weeds in the West — The USGS is conducting a multi-scale, integrative program for mapping infestations and accurately monitoring the spread of exotic plants (i.e., weeds) in western forests and rangelands, improving methods for predicting areas most vulnerable to invasions, assessing the effects of management practices and natural disturbances on invasions, and providing improved methods for reducing the impacts of invasive weeds on native species and for restoring public range lands affected by weed invasions. In riparian areas, integrated methods for regulating stream flow, fire, and other environmental factors are being developed to reduce populations of saltcedar and other exotic trees and restore native vegetation.

Exotics in the East — In FY 1998, the USGS expanded research on exotic species threatening ecosystems and native species in the eastern states.

Effects of exotic rodent and avian diseases documented

Exotic small mammal and invertebrate predators and avian diseases are major factors in the decline of Hawaii's native species. Federal, state, and private land managers give high priority to reducing these threats in Hawaii's conservation areas. In FY 98, USGS scientists completed an analysis of biological and behavioral data on introduced rats in native forests, which is enabling development of more effective management strategies and rodent control techniques (e.g., through ongoing research on the efficacy and safety of aerially-applied rodenticide in native forests). USGS surveys at Hakalau Forest National Wildlife Refuge showed that mid- and low-elevation areas serve as sinks for avian pox and avian malaria, which are affecting the productivity and survival of threatened and endangered forest birds in the high elevation refugia that provide their last remaining habitat. The surveys also documented the role of disturbance by feral pigs in creating larval habitats for the mosquito vectors of these diseases, and showed that land uses and disease transmission in adjacent areas indirectly affect forest bird populations in the refuge itself. The results help managers identify priority areas for controlling feral ungulates and reducing disease transmission in the region.

Improved sampling methods yield new information for addressing threats from exotic plants

Scientists from the Midcontinent Ecological Science Center and Colorado State University have developed new multi-scale vegetation sampling techniques that improve the accuracy and efficiency of biological surveys and monitoring. In comparisons with traditional sampling techniques in various grassland ecosystems, the new methods recorded twice as many species. Using the new methods in national parks and protected areas of the Central Grasslands and Rocky Mountains, scientists have shown that exotic plants are selectively invading "hot spots" of native plant diversity and communities with unique plant species, such as riparian zones, wet meadows, and aspen stands. Studies of grazed and ungrazed areas using the new methods show no significant differences in numbers and cover of native and exotic species in nearly all management areas. Exotic plant species appear to be invading grazed and ungrazed areas equally well. The information from these improved sampling methods will aid early detection of invasive plants, help predict new areas of invasion, guide efforts to control invasive plants, and facilitate restoration of native plants. In cooperation with the USDA, Forest Service, the USGS the improved methods have been used to refine vegetation sampling techniques for the Forest Service's Forest Health Monitoring Program in order to obtain better information on non-native plant invasions in the nation's forests.

These efforts include surveys of exotic species in eastern parks and wildlife refuges, studies of pathways for establishment and spread of invasive species, research on the impacts of invasive species and factors in invasions (e.g., management history, natural and human caused disturbances), and development of methods to control or eliminate exotic species and promote healthy native communities that are resistant to invasion. Particular emphasis is on documenting the impacts of exotic plants and the interactions of native and introduced fishes in the southeast; and the impacts of exotic molluscs on native molluscs in small streams and large rivers.

Great Lakes Invaders — USGS research supports cooperative efforts in the Great Lakes region to prevent and control the spread of invasive fish, reduce the pervasive impacts of zebra mussels on U.S. waterways, and manage or mitigate the adverse ecological and economic impacts of the invaders. Emphasis is on modeling the population dynamics and interactions of invasive exotic species in the Great Lakes including the zebra mussel, European ruffe, and round goby. Research includes development of improved methods for preventing the accidental introduction or spread of exotic species in the Great Lakes ecosystem, and for assessing risks from established exotic species and potential new invaders. USGS research also supports a cooperative efforts to improve control of sea lamprey, including the evaluation and registration of chemical lampricides.

Recent Accomplishments

New Discoveries of Exotic Fish —

Two juvenile blueback herring (*Alosa aestivalis*) were caught in Lake Ontario by USGS Great Lakes Science Center scientists in October 1995, the first record of this anadromous marine fish in the Great Lakes. Blueback herring most likely gained entry to Lake Ontario via the Erie Barge Canal, a navigation canal that links the Mohawk-Hudson Rivers, which drain to the Atlantic Ocean, and Oneida Lake, which drains to Lake Ontario through the Oneida-Oswego Rivers. The species, which spawns in the Hudson River, was first reported from the upper Mohawk River in 1978. Improved water quality in the upper Mohawk River beginning in the mid 1970's may have facilitated the expansion of the spawning range through the Oneida-Oswego River system. Self-reproducing populations of blueback herring have become established in several southern reservoirs. The species thus may have the potential to colonize Lake Ontario, and eventually other Great Lakes, potentially impeding recovery of depressed populations of native fishes, like lake herring (*Coregonus artedii*) and lake trout (*Salvelinus namaycush*), through competition with, or predation on, their larvae. Even if blueback herring do not become

established in Lake Ontario, the occurrence of their juveniles in the lake is evidence that an old pathway, the Erie Canal, has been reopened for exotic aquatic organisms to enter the Great Lakes watershed, apparently due to an improvement in water quality.

Prescribed Fire Offers Promise for Controlling Chinese Tallow —

Chinese tallow tree is rapidly invading native and altered ecosystems in the southern states, and is a particular threat in coastal prairies which have been reduced to less than one percent of their original extent by human activities. Chinese tallow has been thought to become more resistant to fire as it matures. Scientists at the National Wetlands Research Center have recently shown that even large trees can be killed by fire given adequate herbaceous fuel. Results suggest that prescribed burning may be an effective tool for managing invasions, pending further research on methods for managing herbaceous fuel.

Asian Swamp Eel — Fishery

biologists have recently discovered three established populations of the Asian swamp eel (*Monopterus albus*) in the southeastern United States, possibly through release as a pet from aquariums or from tropical fish farms. One population is near Atlanta, Georgia, another south of Tampa, Florida, and one is in the Miami, Dade/Broward counties, Florida, where it poses a potential threat to the Everglades. This eel is a highly adaptable predator, able to breathe air, and move across land. It is tolerant of climatic conditions ranging from tropical to temperate and has the capacity, in time, to spread throughout the southeastern United States. The swamp eel is a voracious predator and once in the wild could compete with or prey upon native fishes.

Exotic Species Information System Continues to Grow — The USGS provides reliable information on exotic species via the Internet. Several databases are being developed. The largest is the Aquatic Non-indigenous Nuisance Species Database, a national database developed and coordinated by the Florida Caribbean Science Center. The database includes all groups of non-indigenous aquatic organisms, both those of foreign origin as well as native species transported outside of their natural range. The growing database contains more than 42,000 documented occurrence records for 920 species, including reliable reporting of new

introductions. The program's website (<http://nas.er.usgs.gov/>) enables users to query the database to obtain maps, fact sheets, and custom reports. Using this database, USGS scientists compiled information on over 500 species of non-indigenous fishes into a book to be published in early 1999 by the American Fisheries Society. The book, titled "Non-indigenous Fishes Introduced into Inland Waters of the United States", contains information on native and introduced range, taxonomy, identification, means of introduction, status and impacts for all fish species known to be introduced into some portion of the United States outside of their native range. Each species account is accompanied by a state-level distribution map showing native and introduced range.

The Pacific Islands Ecological Research Center is developing and coordinating a similar on-line database for exotic species in Hawaii (<http://www.hear.org/AlienSpeciesInHawaii/index.html>).

Access to information on exotic plants is also being provided through USGS databases and web sites for public lands in the Four Corners Area and the Great Plains. The USGS is working with other agencies and organizations in developing a national exotic species information system that facilitates access to, and ultimately integration, of information from many sources. In cooperation with the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, the USGS coordinated publication of a directory of 17 invasive plant databases and a Fact Book by Dr. Randy Westbrooks (APHIS Weed Coordinator on detail to USGS) entitled "*Invasive Plants: Changing the Landscape of America*" -- a detailed compendium of information on invasive plants and their effects on different ecological regions and economic sectors.

Justification for Program Change

Research and Monitoring for Amphibians as an Indicator Species (+\$4.0 million) —

There has been a dramatic decline in amphibian species in disparate habitats. Because amphibians are considered good indicators of ecosystem health due to their sensitivity to many kinds of environmental stress, there is an urgent need to evaluate the scope and severity of this problem. The majority of this proposed increase (\$3.5 million) will be used to create a coordinated, nation-wide monitoring program that will conduct statistically valid amphibian monitoring on DOI lands. Activities will include compiling existing data and information on the distribution and abundance of amphibians and their habitats and conducting additional sampling to document status and to forecast trends. The remaining funds (\$0.5 million) will be used to identify factors causing amphibian declines and deformities. These studies will include the individual and combined impacts of various stressors such as contaminants, disease, global climate change, and the introduction of non-native species.

	FY 2000 Request	Program Change
\$(000)	97,734	-7,010

Hawaii Archipelago (+\$0.7 million) — Because of their geographic isolation, tropical islands have a higher proportion of native species than anywhere else on earth. These unique biological communities are threatened by habitat loss and a growing number of invasive alien species. The proposed increase will expand USGS research to assess the effects of interacting stressors on island ecosystems, and to develop management strategies to improve

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the status of native species. The majority of the increase will be used to determine ecological relationships and habitat requirements of listed and proposed plant species and other rare and declining species of Federal concern in the Hawaiian archipelago. Information on demography and limiting factors of rare plants is needed in order to aid their recovery and the restoration of habitat. The remainder of the increase will enable initiation of research in sensitive aquatic and coastal marine areas of priority Federal concern on Hawaii, Guam, American Samoa, and the Northern Marianas. Emphasis will be on the factors that influence invasions by alien species that are causing significant impacts on native communities through competition and predation.

Coral Reefs (+\$0.4 million) — Recent evidence indicates that coral reefs are deteriorating worldwide. Symptoms include loss of corals, increasing abundance of benthic algae, declining populations of animals that feed on corals, increased coral disease, and increased erosion. The USGS will initiate studies to develop and test existing and emerging technologies to document coral reef health and develop management and policy options for coral reef conservation. The USGS will: 1) map coral reefs, seagrasses and mangroves in U.S. waters, including the distribution of habitats, ecosystems, and major stressors that may impact coral reefs; 2) develop GIS databases of reef habitat and reef fish exploitation, and physical/biological models to assess and predict effects of multiple stressors; and 3) examine factors responsible for overall decline in corals, seagrasses and mangrove systems and implement methodologies to assess and monitor diversity and resources at selected index sites, with particular emphasis on protected areas (e.g., National Marine Sanctuaries, National Parks and National Wildlife Refuges).

Biological research (-\$5.5 million) — A reduction of \$3.5 million will curtail some research in the protection and habitat of at risk groups of species, a part of this type of work may be conducted within the DOI Science Priorities program. Also, a reduction of \$2.0 million will curtail research to provide information on biological impacts and management strategies associated with common water quality problems in a variety of habitats. This reduction is being proposed to fund higher priority needs requested elsewhere in the FY 2000 budget.

Alaska Grant (-\$5.6 million) — This decrease will reduce the level of effort for a grant program to conduct basic marine research on the Bering Sea and those areas in the North Pacific Ocean which have an ecological or physical connection to the Bering Sea (e.g., eastern Chukchi Sea), but may include other areas of the North Pacific. The effort would be decreased from \$6.6 million to \$1 million. In FY 1999, the resources were used for a competitive grant program administered under the direction of the Departments of Interior and Commerce with a by a Steering Committee comprised of the University of Alaska system, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game, and chaired by the USGS.

Training/Travel (-\$0.760) — This reduction will result in providing only the highest priority training and related travel for field biologists, research managers, and other employees.

Leetown HVAC (-\$250,000) — Study and design for replacement of heating, ventilation, and air conditioning (HVAC) system will be completed in FY 1999.